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Structure B-44-16

College Avenue over the Fox River
City of Appleton; Outagamie Co.

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Introduction

Structure B-44-16 carries College Avenue over the Fox River in the City of Appleton. College Avenue is a principle urban arterial with a current ADT of 19,300 vpd, with trucks as 5.4 % of this traffic volume. The projected ADT is between 24,700 vpd (2 lanes) to 30,000 vpd (4 lanes) in the year 2028, depending on the number of traffic lanes carried by the bridge. The bridge currently carries 2 lanes of traffic on a 30 ft roadway width and two 5' sidewalks. The bridge is 1387 ft long with a horizontal curve over the center portion of the structure. The bridge is comprised of 13 spans ranging in span length from 48.5 ft to 151 ft, measured along the centerline of the bridge.

Piers 1 thru 5 and 9 thru 12 are single shaft hammerhead piers. Piers 6, 7, & 8 are two column frames. The superstructure for spans 1 thru 10 is comprised of a concrete bridge deck on continuous welded steel plate girders in a 2 girder framing system (Fracture Critical configuration), spaced 27 ft apart, with floor beams and stringers. The superstructure for spans 11 thru 13 is comprised of a concrete bridge deck on continuous welded steel plate girders, with 4 girder lines at 9 ft spacing.

History

The structure was constructed in 1960. Some of the bridge design, detailing, and construction techniques for steel bridge girders used in the 60's have since been discovered to lead to fatigue problems in steel bridge structures. The combination of fatigue prone details, weld discontinuities, and cyclic loadings from traffic contribute to a considerable reduction in the service life of steel superstructures. This is very evident on this structure, from the fatigue cracking found during past in-depth bridge inspections.

Structures that were designed with non-redundant load paths (Fracture Critical), like the 2-girder framing system used in this bridge, pose additional concern. A failure of one of the main structure members, the welded plate girder in this case, would most likely cause a catastrophic failure: collapse of the bridge structure.

The concrete bridge deck was replaced in 1980 and the superstructure steel was painted in 1982.

In 1992, piers 4, 7 and 10, located under expansion joints, where repaired. Deterioration was and still is occurring from the corrosion of the reinforcing steel.

In 2002, some superstructure retro-fit work was performed in an attempt to extend the service life of the bridge till 2008 and assure that the bridge could remain "fit for service" during the planning, design, and construction of a major rehabilitation to this structure or of a replacement bridge structure. An analysis was performed to determine expected stress ranges and the estimated remaining life at critical locations on the main members of this bridge structure, incorporating in the results of the most current in-depth bridge inspection. Additional steel plates were added in locations where it was questionable whether the existing structure was able to safely carry traffic loads for another 5 years. Details were developed to temporarily arrest existing fatigue cracks.

The bridge is currently scheduled for a more frequent inspection cycle than typical bridges in the State of Wisconsin to monitor the performance of the retro-fit details, assess problems developing in non-retrofitted locations, and to locate any new fatigue cracks that may develop.

Alternatives Considered

Do Nothing:

It is anticipated that if no work is done to this structure that additional fatigue related cracking will be discovered, and will need to be monitored with ever shortening in-depth bridge inspection cycles. Bridge inspection requires portions of the deck to be closed to traffic to provide access for the bridge inspection crew and equipment. This closure of portions of the bridge deck disrupts traffic. The bridge will need to be posted for lower and lower load limits as the bridge's service life comes to an end. Load limits that would restrict semi trailers from using the bridge could be expected in 2008. This would continue until the structure is deemed unfit for service or there are inadequate resources available to continually inspect and monitor the problems. At that point the structure will need to be closed to traffic. This alternative does not adequately serve the long-term needs of the community or the traveling public.

Structure Rehabilitation – Additional steel repairs/retro-fits:

If the existing superstructure is to be maintained beyond 2008, a rigorous engineering analysis should be performed to assess actual stress ranges, remaining fatigue life, and additional retro-fit design in all locations on all of the structural members. Required rehabilitation work would include, but is not limited to; removing portions of the deck over pier locations to allow top girder flanges to be retrofitted (With the deck in place, these critical areas are inaccessible); Retrofitting connections; removing and retrofitting problem welds; retrofitting or replacing diaphragms exhibiting section loss; retrofitting rough cut openings in stringers; abutment repairs; pier repairs; and painting. These recommendations are detailed in the most recent inspection report that is currently available. The cost of all the additional retro-fit work required would exceed the cost of a new bridge and makes it uneconomical to keep this existing structural steel in service.

Even after completion of this rehabilitation work, it is expected that there may be additional fatigue cracks detected and repairs/retro-fits required in the future. There are fatigue cracks currently too small to detect, which given the time and continued cyclic loadings, will grow into a crack size that can be detected during an in-depth inspection. In addition, there would continue to be no load path redundancy for the main structural members (Fracture Critical).

Structure Rehabilitation – Superstructure replacement:

Replacing the welded steel plate girders, floor beams, stringers, & diaphragms of the existing superstructure in spans 1 thru 10, along with the concrete deck, would eliminate the current superstructure problems. Replacing the current 2 girder framing system with a multi-girder framing system would provide load path redundancy to this structure. Utilizing high performance weathering steel would hold down the weight of the new structural steel and limit the need for future painting of the new superstructure. Without widening the substructures, a new superstructure would be limited to the current roadway widths and sidewalk widths.
The pier caps for Piers 6,7, & 8 would need to be strengthened or replaced to carry the loads from the new interior girder lines.

The existing substructures are not capable of supporting a heavier concrete girder superstructure.

Several of the piers would need repair work to address spalling concrete and corrosion of the reinforcement. **It is anticipated that these piers would continue to need repair work**, based on the longevity of the previous pier repair work, approximately every 10 years.

The steel framing in spans 11 thru 13 would require some minor repair work, including painting. Since these span account for such a small portion of the overall structure length, the framing could be replaced with high performance weathering steel to limit future painting & maintenance costs.

This construction cost estimate is based on current (2003 $'s) average square foot structure costs and includes only the structure work. Approach work is not included, nor is engineering and contingencies. The cost estimate assumes the steel in spans 11 thru 13 is replaced.

42'wide x 1387'long x ($56.00/sf + $10.00/sf) =	$3,850,000.
replacement of 3 pier caps -	$ 150,000.
Repair delaminated and spalling pier concrete	$ 50,000.
	$4,050,000.

It is anticipate that the bridge would be closed to traffic during this rehabilitation work.

Structure Rehabilitation – Superstructure replacement and widening:

To achieve a bridge wide enough to handle 4 lanes of traffic, bicycles, and pedestrians, all the bridge substructures would need to be widened. There appears to be a number of constraints that would be challenging to overcome in the design of this alternative, thus the engineering cost would be expected to be considerably higher for this alternative.
Considering a roadway width of 58 ft (including two 5 ft bike lanes) and two 6 ft sidewalks, a bridge deck width of 72 ft would be required.
Note: without providing the accommodations for bicycles, a minimum deck with of 66 ft would be needed.

This construction cost estimate is based on current (2003 $'s) average square foot structure costs and includes only the structure work. Approach work is not included, nor is engineering and contingencies.

Superstructure replacement and repairs	$4,050,000.
Widening 30' x 1387' x $95/sf	$3,950,000.
	$8,000,000.

It is anticipated that the bridge would be closed to traffic during this rehabilitation work.

Structure Replacement – 2-lane structure:

A new prestressed concrete girder superstructure, abutments, and piers could be utilized as a replacement structure. 72" deep continuous prestressed concrete girders can achieve span lengths up to 165 ft spans, reducing the number of piers required in the Fox River. A horizontal curve on the bridge would limit the spans to lengths considerable less than 165 ft..

A roadway width of 36 ft with two 6 ft sidewalks would result in a deck width of 50 ft.

This construction cost estimate is based on current (2003 $'s) average square foot structure costs and includes only the structure work. Approach work is not included, nor is engineering and contingencies.
50' wide x 1390' long x $55/sf = $3,800,000.

If the new structure could be built on an alignment adjacent to the existing alignment, traffic could be maintained on the existing structure during construction of the new bridge.

Structure Replacement – 4-lane structure:

A new prestressed concrete girder superstructure, abutments, and piers could be utilized as a replacement structure. 72" deep continuous prestressed concrete girders can achieve span lengths up to 165 ft spans, reducing the number of piers required in the Fox River. A horizontal curve on the bridge would limit the spans to lengths considerable less than 165 ft..

A roadway width of 58 ft (including two 5 ft bike lanes) with two 6 ft sidewalks would result in a deck width of 72 ft.

This construction cost estimate is based on current (2003 $'s) average square foot structure costs and includes only the structure work. Approach work is not included, nor is engineering and contingencies.
72' wide x 1390' long x $55/sf = $5,500,000.

If the new structure could be built on an alignment adjacent to the existing alignment, traffic could be maintained on the existing structure during construction of the new bridge.

Recommendation

The Wisconsin Department of Transportation recommends that the existing bridge structure be replaced with a new bridge.

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